location along and across the polyimide strip.

In designing a probe for a specific application, one seeks a compromise between (1) minimizing the number of diodes in order to minimize the complexity of input/output connections and external electronic circuitry while (2) using enough diodes to obtain the required precision. Optionally, to minimize spurious heating of the cryogenic fluid, the external circuitry can be designed to apply power to the probe only during brief measurement intervals. Assuming that the external circuitry is maintained at a steady temperature, a power-on interval of only a few seconds is sufficient to obtain accurate data on temperatures and/or the height of the liquid/vapor interface.

This work was done by Mark Haberbusch of Sierra Lobo, Inc., for **Stennis Space Center**.

In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to:

Sierra Lobo, Inc.
11401 Hoover Road
Milan, Ohio 44846

Refer to SSC-00191, volume and number of this NASA Tech Briefs *issue, and the page number.*

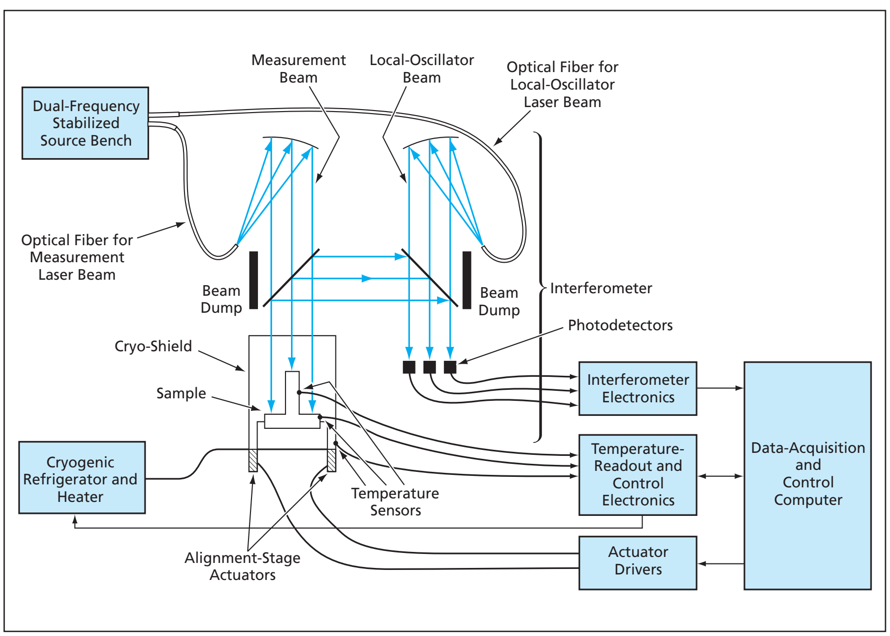
Precision Cryogenic Dilatometer

This instrument offers much greater precision than do other currently available dilatometers.

NASA's Jet Propulsion Laboratory, Pasadena, California

A dilatometer based on a laser interferometer is being developed to measure mechanical creep and coefficients of thermal expansion (CTEs) of materials at temperatures ranging from ambient down to 15 K. This cryogenic dilatometer has been designed to minimize systematic errors that limit the best previously available dilatometers. At its prototype stage of development, this cryogenic dilatometer yields a strain measurement error of 35 ppb or 1.7 ppb/K CTE measurement error for a 20-K thermal load, for low-expansion materials in the temperature range from 310 down to 30 K. Planned further design refinements that include a provision for stabilization of the laser and addition of a high-precision sample-holding jig are expected to reduce the measurement error to 5-ppb strain error or 0.3-ppb/K CTE error for a 20-K thermal load.

The dilatometer (see figure) includes a common-path, differential, heterodyne interferometer; a dual-frequency, stabilized source bench that serves as the light source for the interferometer; a cryogenic chamber in which one places the material sample to be studied; a cryogenic system for cooling the interior of the chamber to the measurement temperature; an ultra-stable alignment stage for positioning the chamber so that the sample is properly positioned with respect to the interferometer; and a data-acquisition and control system. The cryogenic chamber and the interferometer portion of the dilatometer are housed in a vacuum chamber on top of a vibration-isolating optical table in a cleanroom. The sample consists of two pieces — a pillar on a base — both made of the same material. Using reflections of the interferometer beams from the base and the top of the pillar, what is measured is the change in length of the pillar as the temperature in the chamber is changed.



The **Change in Height** of the sample pillar in the cryogenic chamber is measured interferometrically. Design features that are much too numerous to depict here ensure a high degree of optical and mechanical stability over wide temperature range, as needed for high-precision measurements of thermal expansion and creep in the sample.

In their fundamental optical and electronic principles of operation, the laser light source and the interferometer are similar to those described in "Common-Path Heterodyne Interferometers" (NPO-20786), *NASA Tech Briefs*, Vol. 25, No. 7 (July 2001), page 12a, and "Interferometer for Measuring Displacement to Within 20 pm" (NPO-21221), *NASA Tech Briefs*, Vol. 27, No. 7 (July 2003), page 8a. However, the present designs incorporate a number of special geometric, optical, and mechanical features to minimize optical and thermal-expansion effects that contribute to measurement errors. These features include the use of low-thermal-expansion materials for structural components, kinematic mounting and symmetrical placement of optical components, and several measures taken to minimize spurious reflections of laser beams.

This work was done by Matthew Dudik, Peter Halverson, Marie Levine-West, Martin Marcin, Robert D. Peters, and Stuart Shaklan of Caltech for **NASA's Jet Propulsion Laboratory**. *Further information is contained in a TSP (see page 1).*
NPO-40389